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Alternative magnesium source for phosphorous recovery – a feasibility and economic analysis

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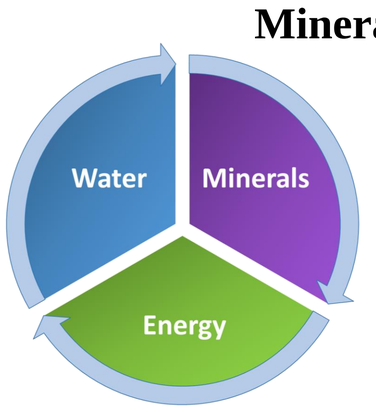
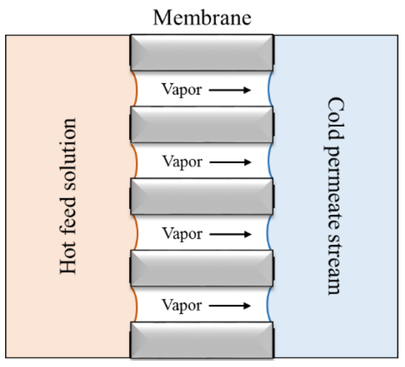
Minerals-water-energy nexus



Sustainability in mineral extraction might be realized by redesigning the conventional mining industry. Minerals can be recovered from waste streams by using membrane crystallization.

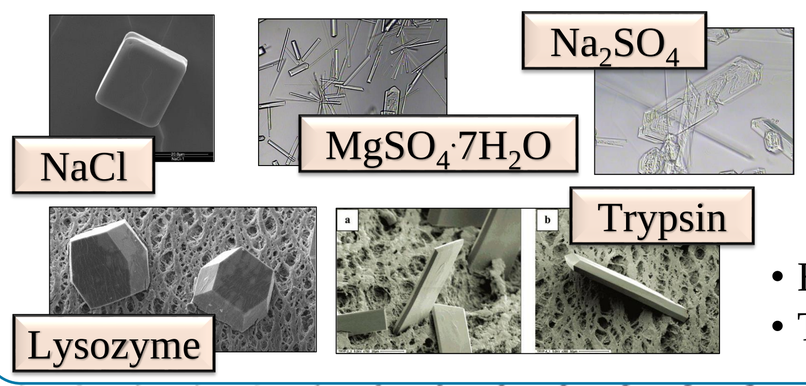
Concept of Membrane Crystallization

- Minor effect of concentration on process performance.
- Potential to use low-grade heat energy.
- High product quality.
  - Theoretical 100 % rejection of non-volatiles.



Membrane Crystallization

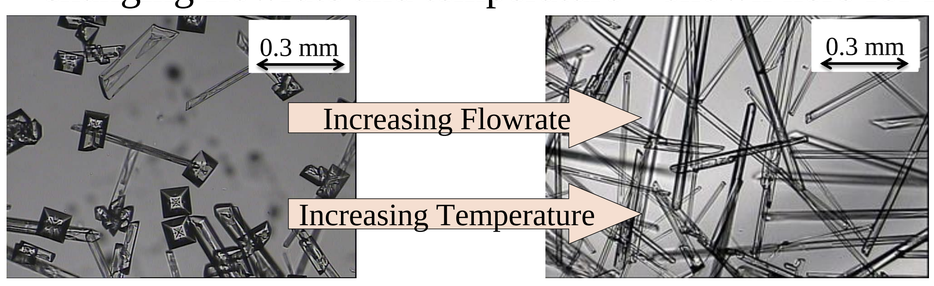
What has been recovered?



- Low CV
- Controlled nucleation and growth
- High purity
- Tunable polymorph

Process control

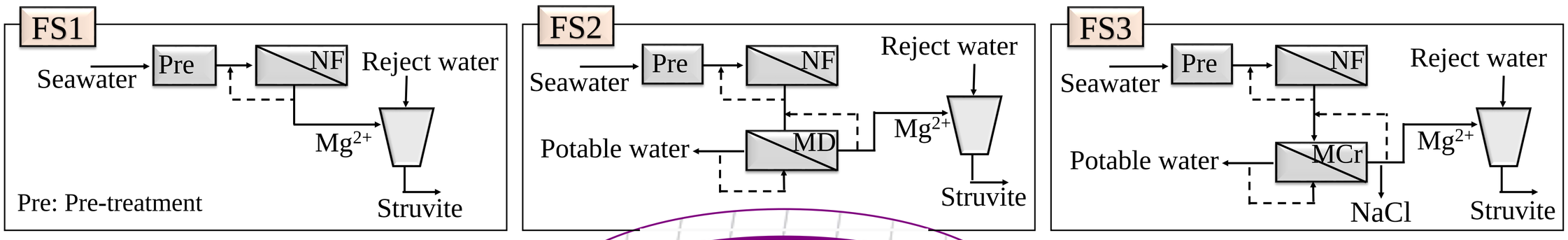
Different polymorphs can be crystallized by changing flowrate and temperature – shown here for LiCl.



Concept of phosphorous recovery

Efficient struvite ($MgNH_4PO_4 \cdot 6H_2O$) recovery requires pH control and a higher magnesium concentration than the one found in wastewater. Instead, magnesium is often added as $MgCl_2 \cdot 6H_2O$. However, this stresses the overall sustainability and economic feasibility. Seawater is a cheap source of magnesium, but chloride ions create problems for the downstream treatment.

Consequently, seawater treatment is required before addition to wastewater.



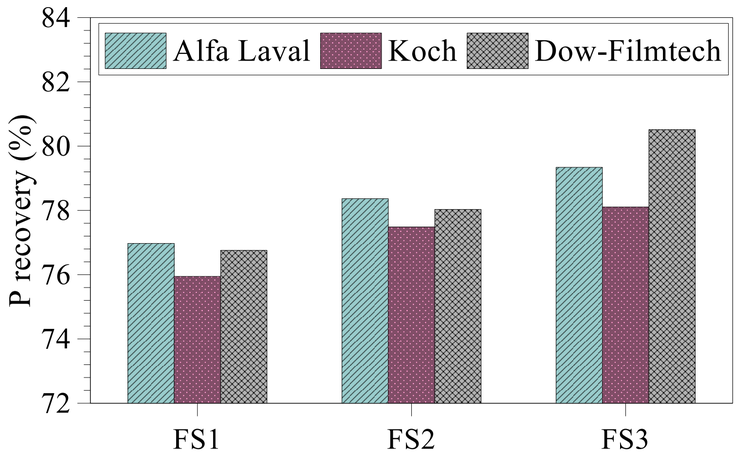
NF: Nanofiltration, MD: Membrane Distillation

MCr: Membrane Crystallization

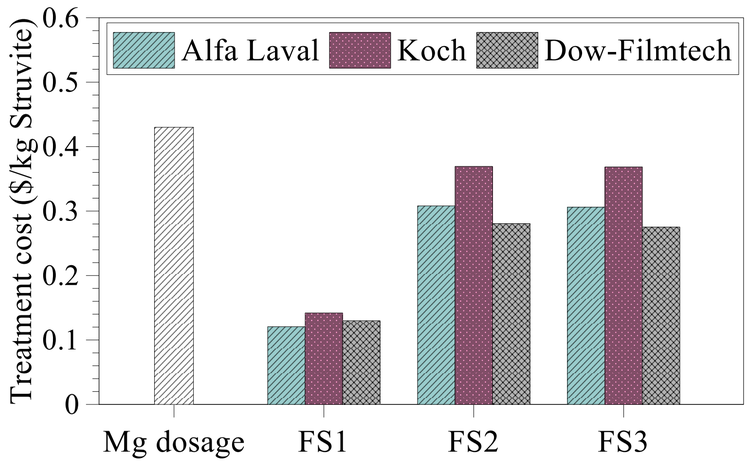
Phosphorous Recovery

Economic analysis

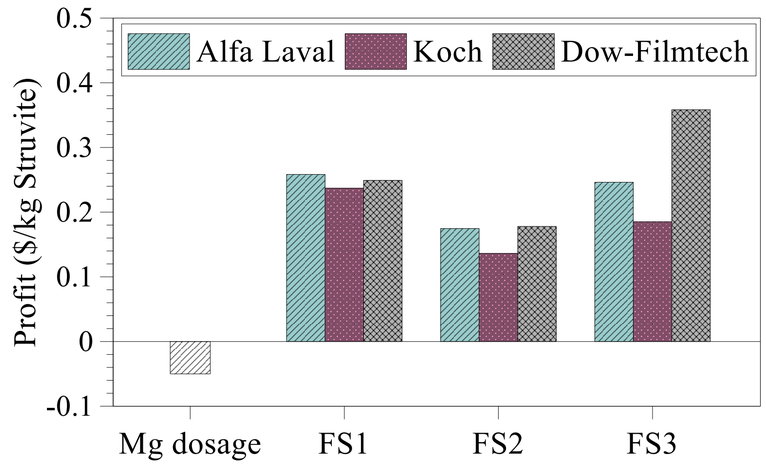
Different treatment options (shown above) and three NF membranes have been considered.



Phosphorous recovery from reject water using treated seawater as magnesium source.



Treatment cost for the different flow sheets and NF membranes.



Profit for the different flow sheets and NF membranes

Conclusion

- All the treatment options are able to recover more than 75 % of phosphorous at pH 7.5 (Theoretical estimations).
- The lowest cost is found to be only NF treatment, whereas MD and MCr require additional cost for the equipment and operation and maintenance costs.
- On the other hand, FS2 produces additional fresh water and FS3 produces fresh water and NaCl.

Acknowledgement

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